

PERFORMANCE AND EMISSIONS CHARACTERISTICS OF ALTERNATIVE
BIODIESEL FUEL ON 4-STROKE MARINE DIESEL ENGINE

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*Special dedicated
to my beloved mother, late father and wife*



PTTA UTHM
PERPUSTAKAAN TUNKU TUN AMINAH

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ABSTRACT

Alternative fuels for diesel engines have become increasingly important due to several socioeconomic aspects, imminent depletion of fossil fuel and growing environmental concerns. Global warming concerns due to the production of greenhouse gases (GHGs) such as carbon dioxide (CO₂) as results from internal combustion engine have seen as one of major factor the promotion of the use of biofuels. Therefore, the use of biodiesel fuel (BDF) as an alternative for fossil diesel (DSL) is among the effective way to reduce the CO₂ emission since it is classified as green and renewable energy. However, it is acknowledged that the use of BDF is restricted due to loss of efficiency and long term problems upon the engine. Hence, a study focussed on investigating the effects of BDF derived from crude palm oil (CPO), jatropha curcas oil (JCO) and waste cooking oil (WCO) blended with DSL at various blending ratio on engine performance and exhaust gas emissions has been performed. This experimental test was done using a small 4-stroke marine diesel engine which operates through engine speeds stimulated at 800, 1200, 1600 and 2000 rpm under 0, 50 and 90% dynamometer loads integrated with emission gas analyser that attached to the exhaust pipeline. As results of experimental investigations, the increment in performance of torque, brake power, brake thermal efficiency (BTE) and brake mean effective pressure (BMEP) while decrease in brake specific fuel consumption (BSFC) has been observed for CPO and JCO fuels comparative to DSL. Meanwhile a contrariwise outcome was obtained for WCO fuels. In conjunction, CPO and JCO promotes lower carbon monoxide (CO) emissions but signified higher nitrogen oxides (NO_x), carbon dioxide (CO₂) and hydrocarbon (HC) emissions compared to DSL. Apart, WCO promotes lower CO, CO₂ and HC emissions but signified higher NO_x emissions compared to DSL. It can be concluded that BDF is useable in diesel engines without engine modifications. The outcomes of this study is significantly contributed as a guidance and reference to the local authority in order to evaluate and select the suitable and optimum BDF for development of policies, regulations and standard.

ABSTRAK

Bahan api alternatif bagi enjin diesel semakin mendapat perhatian disebabkan faktor-faktor sosioekonomi, bahanapi fosil yang semakin berkurangan dan meningkatnya kesedaran terhadap penjagaan alam. Pemanasan global akibat penghasilan gas rumah hijau seperti karbon dioksida (CO_2) daripada enjin pembakaran dalam merupakan faktor besar yang mendorong penggunaan bahanapi bio. Maka, penggunaan bahanapi biodiesel (BDF) sebagai alternatif bagi diesel fosil (DSL) merupakan antara langkah efektif untuk menurunkan CO_2 kerana ia diklasifikasikan sebagai tenaga boleh baharu dan bersih. Namun, diketahui bahawa terdapat kekangan dalam penggunaan BDF seperti hilang kecekapan dan kesan jangka masa panjang terhadap enjin. Oleh itu, satu kajian yang fokus kepada mengkaji kesan-kesan campuran DSL dengan BDF yang dihasilkan daripada minyak mentah kelapa sawit (CPO), minyak pokok jarak (JCO) dan minyak masak terpakai (WCO) pada nisbah campuran yang berbeza terhadap prestasi enjin dan gas-gas ekzos yang terbebas telah dilaksanakan. Kajian ini telah disempurnakan menggunakan sebuah enjin diesel marin 4-lejang kecil yang beroperasi pada kelajuan 800, 1200, 1600 dan 2000 ppm di bawah beban dinamometer pada 0, 50 dan 90% serta telah dipasangkan sekali alat penguji gas ekzos pada paip ekzos. Hasil kajian mendapati bahawa terdapat peningkatan terhadap prestasi enjin dari segi daya kilas, kuasa brek, kecekapan terma brek (BTE) dan tekanan min efektif brek (BMEP) manakala berlaku penurunan penggunaan bahan api spesifik brek (BSFC) bagi bahan api CPO dan JCO berbanding DSL. Sementara itu, hasil yang berlawanan diperoleh bagi bahan api WCO. Sebagai kesinambungan, penggunaan CPO dan JCO membebaskan gas karbon monoksida (CO) yang lebih rendah tetapi pengoksidaan gas nitrogen (NO_x), gas karbon dioksida (CO_2) dan hidrokarbon (HC) yang lebih tinggi berbanding DSL. Selain itu, WCO membebaskan gas CO, CO_2 dan HC yang lebih rendah tetapi NO_x lebih tinggi berbanding DSL. Dapat dirumuskan bahawa BDF boleh digunakan dalam enjin diesel tanpa sebarang modifikasi enjin. Hasil kajian ini sangat berguna sebagai panduan dan rujukan pihak berkuasa tempatan dalam menilai dan membuat pemilihan campuran BDF yang sesuai dan optima dalam pembangunan polisi, peraturan dan piawai.

CONTENTS

TITLE	i
DECLARATION	ii
DEDICATION	iii
ACKNOWLEDGEMENTS	iv
ABSTRACT	v
ABSTRAK	vi
CONTENTS	vii
LIST OF TABLES	xiv
LIST OF FIGURES	xvi
LIST OF SYMBOLS AND ABBREVIATIONS	xxv
CHAPTER 1 INTRODUCTION	1
1.1 Background of study	1
1.2 Problem statement	3
1.3 Objectives of study	4
1.4 Scopes of study	4
1.5 Significant of study	5
1.6 Project time scale	5
CHAPTER 2 LITERATURE REVIEW	6
2.1 Biodiesel fuels	6

2.1.1	Advantages of biodiesel as diesel fuel	8
2.1.2	Disadvantages of biodiesel as diesel fuel	8
2.2	International standard specification for biodiesel	10
2.2.1	Policy and standard adopted for biodiesel in Malaysia	15
2.3	Overview of feedstocks for biodiesel used in the study	18
2.3.1	Oil palm	20
2.3.1	Jatropha curcas	23
2.3.3	Waste cooking oil	24
2.4	Properties of biodiesel fuels	26
2.4.1	Reviews on properties of crude palm oil as compared to diesel fuel	27
2.4.1.1	Evaluation of 5 to 20% biodies blend on heavy-duty common-rail diesel engine	27
2.4.1.2	Performance, emissions and heat losses of palm and jatropha biodiesel blends in a diesel engine	28
2.4.2	Reviews on properties of jatropha curcas oil as compared to diesel fuel	30
2.4.2.1	Biodiesel production from jatropha curcas: A review	30
2.4.2.2	Particle number and size distribution from a diesel engine with jatropha biodiesel fuel	31
2.4.3	Reviews on properties of waste cooking oil as compared to diesel fuel	33
2.4.3.1	Fuel and injection characteristics for a biodiesel type fuel from waste cooking oil	33
2.4.3.2	Performance, emission and combustion characteristics of diesel engine fueled with biodiesel produced from waste cooking oil	34

2.5	Impact of biodiesel fuel on engine performance	35
2.5.1	Reviews on the effects of crude palm oil on engine performance	38
2.5.1.1	Performance and emissions characteristics of diesel engine fuelled by biodiesel derived from palm oil	38
2.5.1.2	Performance and emissions of a diesel engine fueled by biodiesel derived from different vegetable oils and the characteristics of combustion of single droplets	40
2.5.2	Reviews on the effects of jatropha curcas oil on engine performance	42
2.5.2.1	Influence of ethanol blend addition on compression ignition engine performance and emissions operated with diesel and jatropha methyl ester	42
2.5.2.2	Experimental investigations on a jatropha oil methanol dual fuel engine	45
2.5.3	Reviews on the effects of waste cooking oil on engine performance	51
2.5.3.1	Effects of biodiesel derived by waste cooking oil on fuel consumption and performance of diesel engine	51
2.5.3.2	Characteristics of output performance & emission of diesel engine employed common rail fueled with biodiesel blends from wasted cooking oil	54
2.6	Impact of biodiesel fuel properties on exhaust emissions	57
2.6.1	Reviews on the effects of crude palm oil on exhaust emissions	59
2.6.1.1	Experimental investigation of emissions characteristics of small diesel engine fuelled by blended crude palm oil	59

2.6.1.2	Comparative study of performance and emission characteristics of biodiesels from different vegetable oils with diesel	62
2.6.2	Reviews on the effects of jatropha curcas oil on exhaust emissions	65
2.6.2.1	Performance, emission and combustion characteristics of jatropha oil blends in a direct injection CI engine	65
2.6.2.2	Investigation of diesel engine using bio-diesel (methyl ester of jatropha oil) for various injection timing and injection pressure	69
2.6.3	Reviews on the effects of waste cooking oil on exhaust emissions	73
2.6.3.1	Emissions characteristics of small diesel engine fuelled by waste cooking oil	73
2.6.3.2	Comparison of particulate PAH emissions for diesel, biodiesel and cooking oil using a heavy duty DI diesel engine	76
2.7	Critical literature review	79
CHAPTER 3	RESEARCH METHODOLOGY	84
3.1	Introduction	84
3.2	Research methodology flow chart	85
3.3	Biodiesel fuels preparation	86
3.3.1	Procedure and production process of biodiesel	87
3.3.2	Procedure and blending process of biodiesel with diesel fuel	89
3.3.3	Measuring procedure of biodiesel and biodiesel blended fuel properties	91
3.4	Experimental approach	93
3.4.1	Tested engine	93

3.4.2	Emission gas analyser	94
3.5	Experimental setup	96
CHAPTER 4	RESULT AND DISCUSSION	98
4.1	Introduction	98
4.2	Measured properties of tested biodiesel fuel	99
4.3	Analysis of engine performance, combustion characteristics and exhaust emission of diesel engine fuelled by crude palm biodiesel oil	100
4.3.1	Effects analysis of crude palm biodiesel oil on engine performance with respect to the increasing of engine speed at different load condition	100
4.3.2	Effects analysis of crude palm biodiesel oil on engine performance with respect to the increasing of blending ratio at different load condition	102
4.3.3	Combustion analysis of crude palm biodiesel oil at different engine speed and load condition	104
4.3.4	Effects analysis of crude palm oil on exhaust gas emissions with respect to the increasing of engine speed at different load condition	109
4.3.5	Effects analysis of crude palm oil on exhaust gas emissions with respect to the increasing of blending ratio at different load condition	111
4.4	Analysis of engine performance, combustion characteristics and exhaust emission of diesel engine fuelled by jatropha curcas biodiesel oil	113
4.4.1	Effects analysis of jatropha curcas biodiesel oil on engine performance with respect to the increasing of engine speed at different load condition	113
4.4.2	Effects analysis of jatropha curcas biodiesel oil on engine performance with respect to the increasing of blending ratio at different load condition	115

4.4.3	Combustion analysis of jatropha curcas biodiesel oil at different engine speed and load condition	117
4.4.4	Effects analysis of jatropha curcas oil on exhaust gas emissions with respect to the increasing of engine speed at different load condition	121
4.4.5	Effects analysis of jatropha curcas oil on exhaust gas emissions with respect to the increasing of blending ratio at different load condition	123
4.5	Analysis of engine performance, combustion characteristics and exhaust emission of diesel engine fuelled by waste cooking biodiesel oil	125
4.5.1	Effects analysis of waste cooking biodiesel oil on engine performance with respect to the increasing of engine speed at different load condition	125
4.5.2	Effects analysis of waste cooking biodiesel oil on engine performance with respect to the increasing of blending ratio at different load condition	127
4.5.3	Combustion analysis of waste cooking biodiesel oil at different load condition and engine speed	129
4.5.4	Effects analysis of waste cooking oil on exhaust gas emissions with respect to the increasing of engine speed at different load condition	133
4.5.5	Effects analysis of waste cooking oil on exhaust gas emissions with respect to the increasing of blending ratio at different load condition	135
4.6	Comprehensive analysis of engine performance and exhaust gas emission characteristic on diesel engine fuelled by all types of biodiesel blends	137
4.6.1	Comprehensive analysis of all biodiesel blends on engine performance and exhaust gas emissions during 800 rpm	137



4.6.2	Comprehensive analysis of all biodiesel blends on engine performance and exhaust gas emissions during 1200 rpm	140
4.6.3	Comprehensive analysis of all biodiesel blends on engine performance and exhaust gas emissions during 1600 rpm engine speed	143
4.6.4	Comprehensive analysis of all biodiesel blends on engine performance and exhaust gas emissions during 2000 rpm engine speed	146
4.6.5	Summary	149
CHAPTER 5	CONCLUSIONS AND RECOMMENDATION	150
5.1	Conclusions	150
5.1.1	The effects of biodiesel blends fuel on fuel characteristics	150
5.1.2	The effects of crude palm biodiesel oil blends on engine performance and exhaust gas emissions	151
5.1.3	The effects of jatropha curcas biodiesel oil blends on engine performance and exhaust gas emissions	151
5.1.4	The effects of waste cooking biodiesel oil blends on engine performance and exhaust gas emissions	152
5.2	Recommendation	152
	REFERENCES	153
	APPENDICES	159

LIST OF TABLES

2.1	Stoichiometric quantity of methyl alcohol (% vol.)	6
2.2	Potential feedstocks for biodiesel worldwide	7
2.3	Comparison of biodiesel production technologies	9
2.4	ASTM D6751 biodiesel fuel standard	11
2.5	ASTM standards of biodiesel and petrodiesel	11
2.6	European standard, EN 14214 for biodiesel fuel	12
2.7	Status summary of biodiesel in Asian countries	14
2.8	National Biofuel Policy (NBP): Strategic objectives	15
2.9	General applicable requirements and test methods as in MS 2008:2008	17
2.10	Physicochemical properties of palm oil methyl ester, PME fuels test in various ratio blends	28
2.11	Fuel properties of the tested palm biodiesel oil and diesel blends, (PB)	29
2.12	Fatty acid methyl ester (FAME) compositions of the tested biodiesels	29
2.13	Fuel properties of Jatropha oil, Jatropha biodiesel and fossil diesel	30
2.14	Fatty acid composition (FFA) (%) of the seed oil of Jatropha curcas	31
2.15	Basic physical and chemical properties of petroleum diesel, B10, B20 and biodiesel fuels	32
2.16	Physical characteristics of the fuels	33
2.17	Comparative results for B100	34
2.18	Fuel properties of biodiesel in comparison with conventional diesel and waste cooking oil	35

2.19	Literatures summary on the fuel properties, effects on performance and exhaust emissions of biodiesel	79
3.1	Test engine specification	94
3.2	Specification of emission gas analyser model IMR 2800-A	95
4.1	Properties of fuels tested in the experiment	99
4.2	The comprehensive variant on performance and emissions of biodiesel in average relative to diesel fuel	149



LIST OF FIGURES

2.1	Production oil yield for various source of biodiesel feedstocks	19
2.2	Oil palm tree and fruits	21
2.3	Fresh oil palm fruit and its longitudinal section	21
2.4	The example of palm kernel and PKO, and mesocarp and CPO	22
2.5	Jatropha Curcas plant and seed	23
2.6	Grease content in waste cooking oil (WCO)	25
2.7	Transesterificatio reaction of triglycerides	26
2.8	Biodiesel fuel properties and their associated impact	27
2.9	Cumulative heat release at 100% engine load for a medium-duty direct injection (DI) transportation engine	37
2.10	Effects of palm oil blending on engine performance analysis without load conditions	38
2.11	Effects of palm oil blending and engine speed on engine performance and emissions under medium load (50% test load condition)	39
2.12	Engine performance and combustion characteristics with BDF derived from palm oil, rape oil and soy oil	40
2.13	Heat release rates with gas oil and palm oil BDF	41
2.14	Variations in BSFC with blends of ethanol, diesel and JME	42
2.15	Variations in BTE with blends of ethanol, diesel and JME	43
2.16	Variation of cylinder pressure with crank angle for ethanol, diesel and JME	43

2.17	Variation of cumulative heat release with crank angle for ethanol, diesel and JME	44
2.18	Variation of rate of heat release with crank angle for diesel and JME	45
2.19	Variation of BTE with Methanol Energy Share	46
2.20	Variation of volumetric efficiency with methanol energy share	46
2.21	Variation of exhaust gas temperature with methanol energy share	47
2.22	Variation of ignition delay with methanol energy share	47
2.23	Variation of peak pressure with methanol energy share	48
2.24	Variation of MRPR with methanol energy share	48
2.25	Variation of combustion duration with methanol energy share	49
2.26	Variation of heat release rate at maximum efficiency	50
2.27	Effects of biodiesel blending ratio on engine performance (0% load condition)	51
2.28	Effects of biodiesel blending ratio on engine performance (100% load condition)	52
2.29	Effects of engine speed on engine performance (0% load condition)	53
2.30	Effects of engine speed on engine performance (50% load condition)	53
2.31	Output power of different WCO biodiesel blends at two speeds	54
2.32	BSFC of different WCO biodiesel blends at two speeds	55
2.33	Exhaust temperatures of different WCO biodiesel blends at two speeds	56
2.34	Direct impact and corresponding interactions of biodiesel fuel on emissions as compared to fossil diesel	58
2.35	Engine emission during 1500 rpm using OD and biodiesel blends (B5, B10 and B15)	59

2.36	Engine emission during 2000 rpm using OD and biodiesel blends (B5, B10 and B15)	60
2.37	Engine emission during 2500 rpm using OD and biodiesel blends (B5, B10 and B15)	61
2.38	Comparison of NO _x emissions of biodiesels from various sources with diesel	62
2.39	Comparison of CO emissions of biodiesels from various sources with diesel	63
2.40	Comparison of HC emissions of biodiesels from various sources with diesel	63
2.41	Comparison of soot emissions of biodiesels from various sources with diesel	64
2.42	Comparison of CO ₂ emissions of Jatropha oil blend fuelled engines	65
2.43	Comparison of CO emissions of Jatropha oil blend fuelled engines	66
2.44	Comparison of HC emissions of Jatropha oil blend fuelled engines	66
2.45	Comparison of oxygen content in exhaust gas of Jatropha oil blend fuelled engines	67
2.46	Comparison of NO emissions of Jatropha oil blend fuelled engines	67
2.47	Comparison of smoke opacity emissions of Jatropha oil blend fuelled engines	68
2.48	Variation in NO _x emission of different MEOJ blends ratio and diesel at static injection timing in 23°bTDC	69
2.49	Variation in NO _x emission of MEOJ blends (B20 and B80) at different injection timing	70
2.50	Variation in NO _x emission of MEOJ blends (B20 and B40) at different injection pressure	70
2.51	Variation in smoke density of different MEOJ blends ratio and diesel at static injection timing in 23°bTDC	71
2.52	Variation in smoke emission of MEOJ blends (B20 and B80) at different injection timing	71

2.53	Variation in smoke emission of MEOJ blends (B20 and B40) at different injection pressure	72
2.54	Effects of WCO biodiesel blending ratio (vol %) on different engine speed (rpm)	73
2.55	Effects of biodiesel blending with different period of times (at 1500 rpm engine speed)	74
2.56	Effects of biodiesel blending with different period of times (at engine speed from 2000 to 2500 rpm)	75
2.57	Gaseous specific emissions at 23kW, upstream of the catalyst	76
2.58	Gaseous specific emissions at 23kW, downstream of the catalyst	77
2.59	Gaseous specific emissions at 47kW, US catalyst	77
2.60	Gaseous Specific Emissions at 47kW, DS catalyst	78
3.1	Flow chart of overall research works	85
3.2	Biodiesel pilot plant in UTHM, Batu Pahat Johor	86
3.3	General flow-sheet for production of biodiesel	87
3.4	Block diagram of biodiesel production flow	88
3.5	Illustration of equipment apparatus setup for blending process	89
3.6	Block diagram of blending process	89
3.7	Schematic diagram of biodiesel blending process	90
3.8	Kinematic viscosity tester model Hydromotion Viscolite 700	91
3.9	Instrument analysis of flash point, Pensky-Martens model PMA 4	92
3.10	Yanmar TF120-ML diesel engine	93
3.11	IMR 2800-A model gas analyser	95
3.12	Schematic of experimental setup	96
4.1	Effects of engine speed on engine performance by CPO without load condition	101

4.2	Effects of engine speed on engine performance by CPO under 50% load condition	101
4.3	Effects of engine speed on engine performance by CPO under 90% load condition	101
4.4	Effects of CPO blending ratio on engine performance without load condition	103
4.5	Effects of CPO blending ratio on engine performance under 50% load condition	103
4.6	Effects of CPO blending ratio on engine performance under 90% load condition	103
4.7	Combustion characteristic of CPO during 800 rpm engine speed without load condition	105
4.8	Combustion characteristic of CPO during 1200 rpm engine speed without load condition	106
4.9	Combustion characteristic of CPO during 1200 rpm engine speed under 50% load condition	106
4.10	Combustion characteristic of CPO during 1600 rpm engine speed under 50% load condition	107
4.11	Combustion characteristic of CPO during 2000 rpm engine speed under 50% load condition	108
4.12	Combustion characteristic of CPO during 2000 rpm engine speed under 90% load condition	108
4.13	Effects of engine speed on exhaust gas emissions by CPO without load condition	110
4.14	Effects of engine speed on exhaust gas emissions by CPO under 50% load condition	110
4.15	Effects of engine speed on exhaust gas emissions by CPO under 90% load condition	110
4.16	Effects of CPO blending ratio on exhaust gas emissions without load condition	112
4.17	Effects of CPO blending ratio on exhaust gas emissions under 50% load condition	112
4.18	Effects of CPO blending ratio on exhaust gas emissions under 90% load condition	112

4.19	Effects of engine speed on engine performance by JCO without load condition	114
4.20	Effects of engine speed on engine performance by JCO under 50% load condition	114
4.21	Effects of engine speed on engine performance by JCO under 90% load condition	114
4.22	Effects of JCO blending ratio on engine performance without load condition	116
4.23	Effects of JCO blending ratio on engine performance under 50% load condition	116
4.24	Effects of JCO blending ratio on engine performance under 90% load condition	116
4.25	Combustion characteristic of JCO during 800 rpm engine speed without load condition	117
4.26	Combustion characteristic of JCO during 1200 rpm engine speed without load condition	118
4.27	Combustion characteristic of JCO during 1200 rpm engine speed under 50% load condition	118
4.28	Combustion characteristic of JCO during 1600 rpm engine speed under 50% load condition	119
4.29	Combustion characteristic of JCO during 1600 rpm engine speed under 90% load condition	120
4.30	Combustion characteristic of JCO during 2000 rpm engine speed under 90% load condition	120
4.31	Effects of engine speed on exhaust gas emissions by JCO without load condition	122
4.32	Effects of engine speed on exhaust gas emissions by JCO under 50% load condition	122
4.33	Effects of engine speed on exhaust gas emissions by JCO under 90% load condition	122
4.34	Effects of JCO blending ratio on exhaust gas emissions without load condition	124
4.35	Effects of JCO blending ratio on exhaust gas emissions under 50% load condition	124

4.36	Effects of JCO blending ratio on exhaust gas emissions under 90% load condition	124
4.37	Effects of engine speed on engine performance by WCO without load condition	126
4.38	Effects of engine speed on engine performance by WCO under 50% load condition	126
4.39	Effects of engine speed on engine performance by WCO under 90% load condition	126
4.40	Effects of WCO blending ratio on engine performance without load condition	128
4.41	Effects of WCO blending ratio on engine performance under 50% load condition	128
4.42	Effects of WCO blending ratio on engine performance under 90% load condition	128
4.43	Combustion characteristic of WCO during 800 rpm engine speed without load condition	129
4.44	Combustion characteristic of WCO during 1200 rpm engine speed without load condition	130
4.45	Combustion characteristic of WCO during 1200 rpm engine speed under 50% load condition	130
4.46	Combustion characteristic of WCO during 1600 rpm engine speed under 50% load condition	131
4.47	Combustion characteristic of WCO during 1600 rpm engine speed under 90% load condition	132
4.48	Combustion characteristic of WCO during 2000 rpm engine speed under 90% load condition	132
4.49	Effects of engine speed on exhaust gas emissions by WCO without load condition	134
4.50	Effects of engine speed on exhaust gas emissions by WCO under 50% load condition	134
4.51	Effects of engine speed on exhaust gas emissions by WCO under 90% load condition	134
4.52	Effects of WCO blending ratio on exhaust gas emissions without load condition	136

4.53	Effects of WCO blending ratio on exhaust gas emissions under 50% load condition	136
4.54	Effects of WCO blending ratio on exhaust gas emissions under 90% load condition	136
4.55	Performance of diesel engine by all types of biodiesel blends during 800 rpm engine speed without load condition	138
4.56	Performance of diesel engine by all types of biodiesel blends during 800 rpm engine speed under 50% load condition	138
4.57	Performance of diesel engine by all types of biodiesel blends during 800 rpm engine speed under 90% load condition	138
4.58	Emissions characteristic by all types of biodiesel blends during 800 rpm engine speed without load condition	139
4.59	Emissions characteristic by all types of biodiesel blends during 800 rpm engine speed under 50% load condition	139
4.60	Emissions characteristic by all types of biodiesel blends during 800 rpm engine speed under 90% load condition	139
4.61	Performance of diesel engine by all types of biodiesel blends during 1200 rpm engine speed without load condition	141
4.62	Performance of diesel engine by all types of biodiesel blends during 1200 rpm engine speed under 50% load condition	141
4.63	Performance of diesel engine by all types of biodiesel blends during 1200 rpm engine speed under 90% load condition	141
4.64	Emissions characteristic by all types of biodiesel blends during 1200 rpm engine speed without load condition	142
4.65	Emissions characteristic by all types of biodiesel blends during 1200 rpm engine speed under 50% load condition	142
4.66	Emissions characteristic by all types of biodiesel blends during 1200 rpm engine speed under 90% load condition	142

4.67	Performance of diesel engine by all types of biodiesel blends during 1600 rpm engine speed without load condition	144
4.68	Performance of diesel engine by all types of biodiesel blends during 1600 rpm engine speed under 50% load condition	144
4.69	Performance of diesel engine by all types of biodiesel blends during 1600 rpm engine speed under 90% load condition	144
4.70	Emissions characteristic by all types of biodiesel blends during 1600 rpm engine speed without load condition	145
4.71	Emissions characteristic by all types of biodiesel blends during 1600 rpm engine speed under 50% load condition	145
4.72	Emissions characteristic by all types of biodiesel blends during 1600 rpm engine speed under 90% load condition	145
4.73	Performance of diesel engine by all types of biodiesel blends during 2000 rpm engine speed without load condition	147
4.74	Performance of diesel engine by all types of biodiesel blends during 2000 rpm engine speed under 50% load condition	147
4.75	Performance of diesel engine by all types of biodiesel blends during 2000 rpm engine speed under 90% load condition	147
4.76	Emissions characteristic by all types of biodiesel blends during 2000 rpm engine speed without load condition	148
4.77	Emissions characteristic by all types of biodiesel blends during 2000 rpm engine speed under 50% load condition	148
4.78	Emissions characteristic by all types of biodiesel blends during 2000 rpm engine speed under 90% load condition	148

LIST OF SYMBOLS AND ABBREVIATIONS

%	-	Percentage
$^{\circ}\text{C}$	-	Degree Celsius (temperature unit)
$^{\circ}\text{CA}$	-	Degree crank angle
AIST	-	National Institute of Advanced Industrial Science and Technology, Japan
AMP	-	Accumulation mode particles
ANP	-	Agência Nacional de Petróleo, Brazil
ASTM	-	American Society for Testing and Materials
ASTM D975	-	American Standards for Testing Materials for diesel fuel
ASTM D6751	-	American Standards for Testing Materials for B100 biodiesel
aTDC	-	After top dead center
ATDC	-	After top dead center
B0	-	100% diesel content
B5	-	5% biodiesel blend with 95% diesel content
B10	-	10% biodiesel blend with 90% diesel content
B15	-	15% biodiesel blend with 85% diesel content
B20	-	20% biodiesel blend with 80% diesel content
B30	-	30% biodiesel blend with 70% diesel content
B40	-	40% biodiesel blend with 60% diesel content
B50	-	50% biodiesel blend with 50% diesel content
B80	-	80% biodiesel blend with 20% diesel content
B100	-	100% biodiesel content
bar	-	Pressure unit
BDF	-	Biodiesel fuel
BHP	-	Brake horse power
BIS	-	Bureau of Indian Standards
BMEP	-	Brake mean effective pressure
BO	-	Bleach oil

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